Design and Development of Low Cost Groundnut Decorticating Machine for Home and Commercial Use in Nigeria

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Abstract- This work is aim at the design and development of a low cost groundnut decorticating machine for home and commercial use in Nigeria.4.36Kg of roasted groundnut was fed into the machine; this produces an average mass of 3.43Kg of peeled roasted groundnut seeds, 0.462Kg of unpeeled groundnut seeds,0.399Kg of partially peeled groundnut seed and 0.07Kg of broken groundnut seed. An average time of 488.8seconds and an average peeling efficiency of 78.46% was recorded. It was observed that the higher the mass of the roasted groundnut seeds the longer the time of peeling. The machine is cheap because the parts are locally fabricated. The technology could provide employment and at the same time make available quality roasted groundnut seeds at low cost for domestic and commercial use in Nigeria.

Index Terms- Design and Development, Low Cost Groundnut Decorticating Machine, Local Materials, Home and Commercial Use, Nigeria.

I. INTRODUCTION

Nigeria is the third highest producer of groundnut in the world after China and India with a production of 16,114,231, 6,933,000 and 2,962,760 tons respectively [1]. Between 1950s and 1970s before the discovery of oil, Nigeria contributed 50% and 30% of African and World exports[1].In Nigeria, the crop is presently grown throughout the country with the exception of the riverine and swampy areas [2]. In Nigeria, the leading producing states include Niger, Kano, Jigawa, Zamfara, Kebbi, Sokoto, Katsina, Kaduna, Adamawa, Yobe, Borno, Taraba, Plateau, Nasarawa, Bauchi, and Gombe States ([3]; [4]). Groundnut has contributed immensely to the development of the Nigerian economy. From 1956 to 1967, groundnut products including cake and oil accounted for about 70% of total Nigeria export earnings, making it the country's most valuable single export crop ahead of other cash crops like cotton, oil palm, cocoa and rubber ([2];[3]). Presently, it provides significant sources of cash through the sales of seeds, cakes, oil and haulms [5]. Groundnut contains 48-50% oil, 26-28% protein and 11-27 % carbohydrate, minerals and vitamin and it is an important diet for both man and livestock ([6]; [7].).

In Nigeria groundnut is mainly decorticated by hands (Traditional method). This method is not hygienic as dirt from the hands and mouth could pose health risk from the nuts. Moreover it is cumbersome and not effective for bulk decorticatingand is time consuming. The output got from this method is very low and it does not fulfill the market demand because it is a time consuming process. In other to solve the problems cited above, there is need to develop a groundnut decorticating (peeling) machine that will be utilized in the peeling of roasted groundnut efficiently and with little effort in much lesser time and most importantly at a cheap price. The aim of this research work is to develop and designan improved groundnut decorticating machine for home and commercial use in Nigeria.

II. DESIGN ANALYSIS AND CALCULATIONS

DISTANCE BETWEEN DRIVEN AND DRIVING PULLEY

The distance between driving and driven pulley is given as:

$C=2D_1+D_2$ (1)

Where;
D_1 = Diameter of the driver = 0.15m
D_2 = Diameter of the driving = 0.25m
C= Distance between driving pulley and driven pulley
Therefore;
$C=2\times0.15+0.25 = 0.55m$

DETERMINATION OF BELT LENGTH

The belt length can be obtained as follow:

$$L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{D_1+D_2}{4C} \quad \text{(II)}$$

$$= 2 \times 0.55 + \frac{\pi}{2} + \frac{(0.15+0.25)}{4 \times 0.55} = 1.91m$$

DESIGN FOR SPEED RATIO FOR BELT DRIVE

It can be expressed mathematically as:

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{(III)}$$

Where;
D_1 = diameter of the driver = 0.150m
D_2 = diameter of the follower = 0.250m
N_1 = speed of the driver = 1440rpm
N_2 = speed of the follower =?
Therefore;

$$N_2 = \frac{(1440 \times 150)}{250} = 864rpm$$

DETERMINATION OF LAP ANGLE

The equation is expressed as follow:

$$\alpha = 180 \pm 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right) \quad \text{(IV)}$$

Where;
α = Angle of lap
C = Distance between driving pulley and driven pulley

For open belt angle of lap,

$$\alpha = 180 - 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right)$$

Therefore;

$$\alpha = 180 - 2\sin^{-1}\left(\frac{0.25-0.15}{2\times0.55}\right) = 129.6^0 = 2.26rad$$

DETERMINATION OF BELT TENSION

The belt tension can be calculated as follow:

$$2.3log\left(\frac{T_1}{T_2}\right) = \mu\alpha \quad \text{(V)}$$

Where;

α = angle of wrap of an open belt
μ= coefficient of friction = 0.47
T_1= Tension in the tight side of the belt
T_2= tension in the slack side of the belt

Also;

$$P = (T_1 - T_2)V \quad \text{(VI)}$$

Where;
P = Belt power (watts)
V = Belt speed (m/sec)

T_1 and T_2 are tension on the tight and slack sides respectively (N)
Therefore;

$$1331.25 = (T_1 - T_2)11.31$$

$$T_1 - T_2 = \frac{1500}{11.31} = 132.63 \quad \text{(VII)}$$

Also;

$$2.3log\frac{T_1}{T_2} = 0.47 \times 2.26$$

$$log\frac{T_1}{T_2} = \frac{0.47 \times 2.26}{2.3} = 0.462$$

$$\frac{T_1}{T_2} = e^{0.462} = 1.59$$

$$T_1 = 1.59T_2 \quad \text{(VIII)}$$

From equation (VII),

$$T_1 = 132.63 + T_2 \quad \text{(IX)}$$

Combining equation (VIII) and (IX), $1.59T_2 = 132.63 + T_2$

$$T_2 = \frac{132.63}{0.59} = 224.80N$$

Hence;

$$T_1 = 132.63 + 224.8 = 357.43N$$

However;

$$T = T_1 + T_2 = 357.43 + 224.80 = 582.23N$$

DETEREMINATION OF POWER

The power is calculated as follow:

$$P = F\frac{\pi DN}{60} \quad \text{(X)}$$

Where;
P = Power to turn the shaft
V = Speed
F= Force
D= Diameter
N= Speed in revolution per minute
Therefore;

$$V = \frac{3.142 \times 0.15 \times 1440}{60} = 11.31m/sec$$

Also;

$$P = \frac{58.86 \times 3.142 \times 0.15 \times 1440}{60} = 665.78watts$$

But;
750watts = 1hp
This implies that:
665.78 watts = 0.887hp

III. II.TEST AND RESULTS

The roasted groundnut seeds were fed into the decorticating chamber through the hopper. The fixed conveyor cloth with foam underneath mainly to protect the roasted ground from crunching during peeling is attached to both the driver and driven end of the shaft. Peeling of roasted groundnuts commence once the machine is on and the electric motor start rotating from the driverend. The time taken to complete the peeling was noted using the stop watch and also recorded. The peeled roasted groundnut seeds collected were weighed on the weighing balance. The unpeeled, partially and broken seeds were also collected and weighed. The test was repeated fourteen (14) more times with masses of groundnuts that vary from 3.45Kg to 4.65Kg. Table one (1) showed the results obtained with groundnut decorticating machine.

Table 1: Result obtain with groundnut decorticating machine

S/N	M_1 (kg)	M_2 (kg)	M_3 (kg)	M_4 (kg)	M_5 (kg)	T (Sec)	PE (%)
1	4.50	3.65	0.40	0.35	0.I0	503	81.11
2	4.40	3.11	0.39	0.45	0.05	480	70.68
3	4.35	3.36	0.48	0.43	0.08	475	77.24
4	4.45	3.40	0.62	0.51	0.11	486	76.40
5	4.30	3.51	0.43	0.33	0.03	471	81.62
6	4.60	3.59	0.51	0.37	0.13	526	78.04
7	4.50	3.54	0.53	0.44	0.09	506	78.67
8	4.60	3.51	0.52	0.45	0.12	530	76.30
9	4.30	3.36	0.45	0.42	0.07	473	78.14
10	4.43	3.51	0.46	0.41	0.05	480	79.23
11	4.25	3.47	0.39	0.36	0.03	462	81.65
12	4.65	3.60	0.45	0.47	0.13	535	77.42
13	4.44	3.58	0.46	0.38	0.02	486	80.63
14	4.25	3.44	0.43	0.35	0.03	461	80.94
15	3.45	2.76	0.42	0.26	0.01	458	78.86
Σn=15	**Σ M_1=65.47**	**Σ M_2=51.39**	**Σ M_3=6.94**	**Σ M_4=5.98**	**Σ M_5=1.05**	**Σ T=7332**	**Σ PE=1176.93**
	A=4.36	**A=3.43**	**A=0.462**	**A= 0.399**	**A=0.07**	**A=488.8**	**A=78.46**

Where:
M_1 =Total mass of rusted groundnut seeds fed into the hopper (kg)
M_2 = Mass of peeled roasted groundnut seeds (kg)
M_3 =Mass of unpeeled groundnut seeds (Kg)
M_4 =Mass of partially peeled groundnut seeds (kg)
M_5 =Mass of broken groundnut seeds (kg)
T = Time taken to peel the roasted groundnut

PE = Peeling Efficiency = $\frac{M_2}{M_1} \times 100\%$

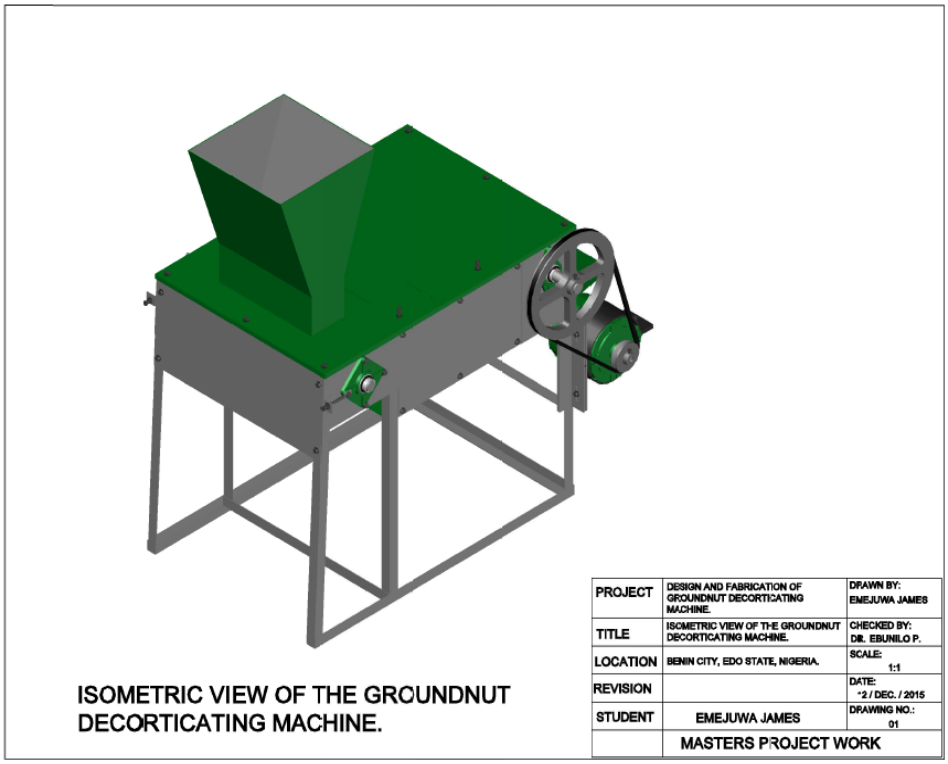
IV. DISCUSSION

The results of decorticating operation on the roasted groundnut seeds is shown in Table 4.1.The average mass of 4.36kg of roasted groundnut was fed into the machine; this produces an average mass of 3.43kg of peeled roasted groundnut seeds, 0.462kg of unpeeled groundnut seeds,0.399kg of partially peeled groundnut seed and 0.07kg of broken groundnut seed. An average time of 488.8seconds and an average peeling efficiency of 78.46% were recorded. It was observed that the higher the mass of the roasted groundnut seeds the longer the time of peeling. The problems encountered with traditional method of decorticating groundnut in Nigeria were overcome in this machine.

V. CONCLUSION

This work presents the design and development of an electrically powered roasted groundnut decorticating machine for home and commercial use in Nigeria. The roasted groundnut decorticating machine can be used for local production, light in weight; operation is easy, repair and maintenance is cheap because the parts are locally fabricated. The operational and process performance showed that the machine peeled with an average efficiency of 78.46%. The technology could provide employment and at the same time make available quality roasted groundnut seeds at low cost for domestic and commercial use.

APPENDIX



Isometric view of the groundnut decorticating machine

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